

THE IMMEDIATE EFFECT OF TOBACCO SMOKE ON
THE LEARNING OF ALBINO RATS

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INTRODUCTION¹

The influence of tobacco smoke on man has been a source of controversy since the introduction of tobacco into Europe. Scientific interest in this problem is of recent origin and as a consequent very little is known about it.

Experiments attempting to discover the psychological effects of tobacco have been hampered by the difficulty of controlling such factors as interest, suggestion, and prejudice. These factors do not enter into experiments with animals. It was thought worthwhile, therefore, to investigate the effects of tobacco smoke on the learning of some animal. The investigation was undertaken to solve no problem beyond this particular one. It was hoped, however, that the results might indicate what would happen to a learning organism when the factors of interest, suggestion and prejudice were eliminated.

APPARATUS

The chief difficulty of this investigation was to devise a technique that would approximate human smoking. This was attempted in the manner set forth below.

An air-tight box (fig. 1), 21 inches long, 20 inches wide, and 14 inches deep, was constructed with a valve on one end branching into two openings, each 1 inch in diameter. A glass pipe containing tobacco was connected to one of these openings by means of a rubber tube. This pipe was 6 inches in length and 1 inch

¹ The author wishes to express his appreciation to Dr. Roy M. Dorcus for his suggestions concerning the problem and his supervision during the investigation.



in diameter. The other branch was used as a fresh air inlet. An adjustable shield on this opening controlled the amount of air that mixed with the smoke. This was set to cover three-fourths of the opening so that the area of the fresh air inlet was approximately 2 square inches, whereas the area of the smoke inlet was about 0.8 square inch which was the size allowed by

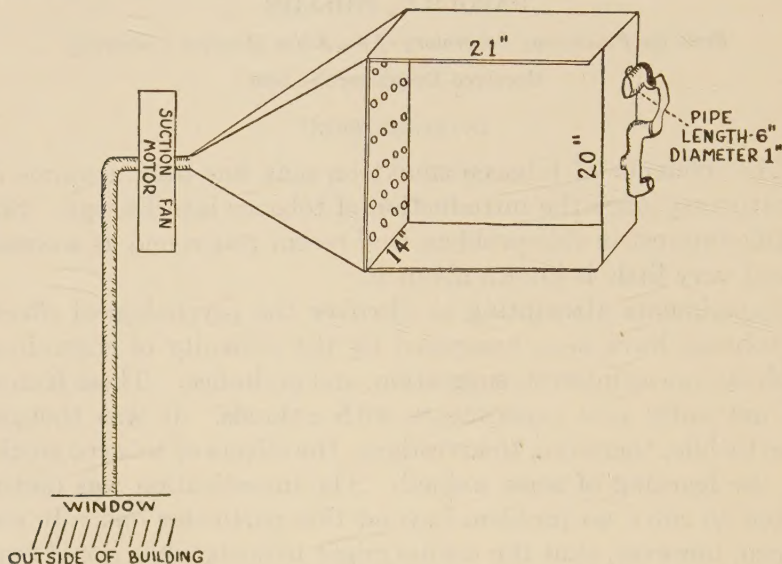


FIG. 1. EXHAUST BOX

TABLE 1

	MILLIVOLTS	TRANSMISSION	DENSITY
Smoke-free box.....	0	1.00	0
First concentration.....	2	0.97	0.013
Second concentration.....	8	0.935	0.029

the pipe stem. Twenty holes one-eighth inch in diameter were bored into the other end of the box, and its exterior was covered by a metal hood. This hood converged to an opening 1½ inches in diameter and fitted a pipe leading to a suction fan. The speed of the motor driving this fan controlled the concentration of smoke drawn through the box. The speed of the motor was regulated by an adjustable rheostat. A pane of glass served as

a top for the box. It fitted tightly on ledges within the box and could be drawn off from one end.

The concentration of the smoke being drawn through the box was estimated by means of a Weston photronic cell connected to a millivoltmeter. The cell was placed in the bottom of the box, and a 21-candle power lamp operated at 6 volts was placed 10 inches from it. Readings were then taken on the voltmeter when the box was free from smoke and when smoke was present. From these observations were calculated the light transmission and the optical density of the smoke-layer. The transmission

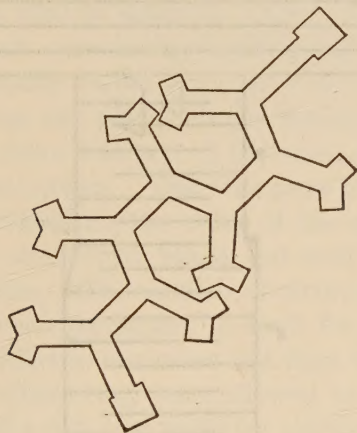


FIG. 2. MULTIPLE "Y" MAZE

of a medicum refers to the ratio of the transmitted to the incident light, while the optical density is defined as the logarithm of the reciprocal of the transmission. If T = transmission and E = density, then $D = \log \frac{I}{T}$. Table 1 expresses the relative values of the smoke-free box and the two concentrations of smoke employed in the investigation.

Warden's multiple Y maze (1), with seven sections to the true path and seven culs-de-sac, was used as the first learning problem. This is illustrated in figure 2. The second problem was a simple alternation box, mounted on an electric grid. This is illustrated in figure 3. The shock used was 0.15 milliamperes.

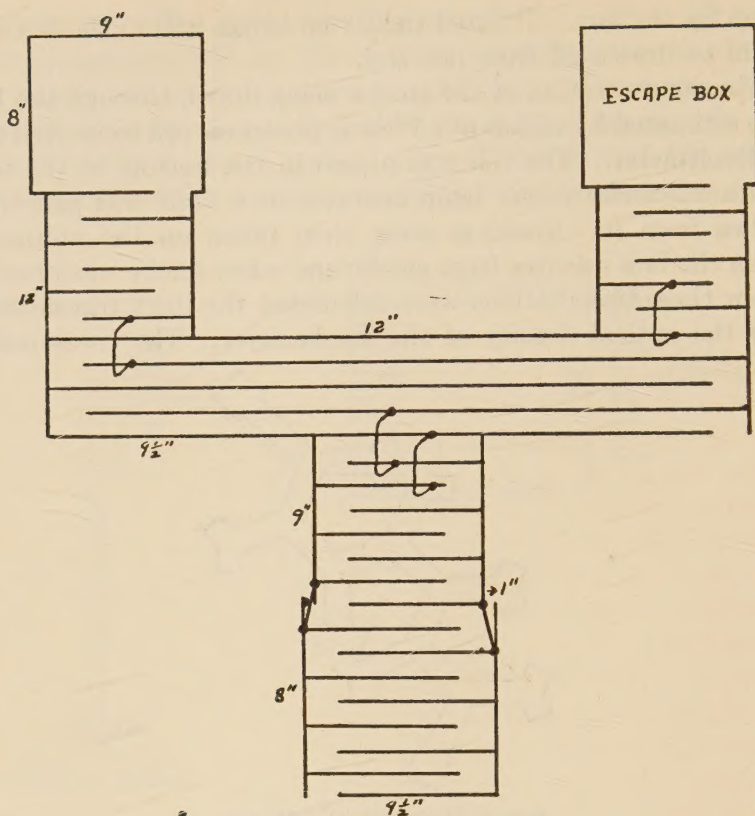


FIG. 3. ALTERNATION PROBLEM

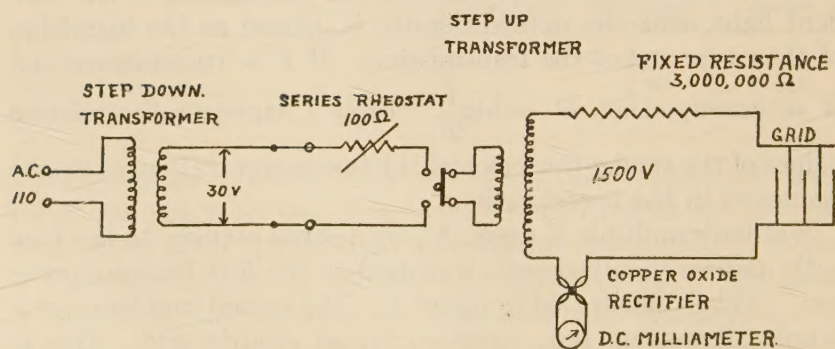


FIG. 4. CIRCUIT FOR GRID

This current was adopted on the basis of earlier work by Dunlap (2). Figure 4 shows the wiring for the shock circuit. A high voltage and a high external resistance were used. The high external resistance makes the variations in the resistance of the rats negligible. The high voltage does no harm. The only difference between the high and low voltage is that the high voltage with the current 0.15 milliampere throws a spark nearly a millimeter as the animal approaches the grid.

PROCEDURE

Albino rats were used as subjects. Litter mates were divided into two groups: an experimental group and a control group. The age of the animals varied from sixty to eighty days.

The control group was placed in the smoke box for forty-five minutes, and the motor was run at the same speed as that used for the experimental group. This was done to avoid any difference that might arise from the noise of the motor or from the procedure. They were then taken out and run through the multiple Y-type maze. The number of errors and the time were recorded. They were permitted to feed for three minutes in the food box connected to the maze and then transferred to individual food boxes where they were allowed to feed for forty-five minutes. One trial a day was given for thirty days.

After thirty trials they were taken off the limited diet and three days later given the alternation problem. The rat was placed in the starting box of this apparatus and was required to run to either of the escape boxes. On the initial run the doors of both boxes were closed. As soon as a choice was made, either to the right or to the left, the door on the opposite side was opened, and the animal had partially to retrace its path in returning to the exit. The animal now had to learn to go directly to the exit. When five successive correct trials were made, the exit which had been opened was closed and the opposite exit opened. The old position habit had to be broken down and a new one established. The standard of mastery was the same as before. The position was again changed in the manner just described. Performances were scored in terms of trials and errors.

This same procedure was followed with experimental animals except that smoke was drawn through the box during their forty-five-minute period in it. Groups I, II, and III were exposed to the light concentration of smoke, and Groups IV and V were exposed to the heavy concentration.

Five groups of animals were used. Each group was composed of experimental and control animals. The experimental animals were exposed to smoke for a forty-five-minute period, and the control animals were placed in a smoke-free box for the same length of time.

All the animals were given two learning problems: the multiple Y maze and the alternation box. Individual records were kept for each animal. In the multiple Y maze the number of errors and the time consumed in completing each trial were recorded. In the alternation box the number of trials and errors were recorded.

Two concentrations of smoke were used. The smokers in groups I, II, and III were exposed to the relatively light concentration of smoke, and the smokers in group IV and V were exposed to the relatively heavy concentration. The other conditions to which these animals were subjected were the same.

RESULTS

For purposes of comparison the scores of groups I, II, and III were considered together and the scores for the smokers in groups IV and V were also massed together. These groups were then compared with their respective non-smoking groups.

The points of comparison were: the errors and time spent in completing the multiple Y maze and the number of trials and errors in the alternation box. In each comparison the total score the standard deviation, the mean, the probable error of the mean, and the critical ratio is given.

The mean number of errors per trial for groups I, II, and III in the multiple Y maze is illustrated in figure 5. There is a fluctuation between the two curves throughout the graph, but, in general, the curve for the non-smokers is lower. The separate means for the groups (table 2) also indicate the same trend,

but when the critical ratio for the means of the three combined groups is considered it is found to be only 0.898.

The time for groups I, II, and III to complete the thirty trials in the multiple Y maze, is given in table 3.

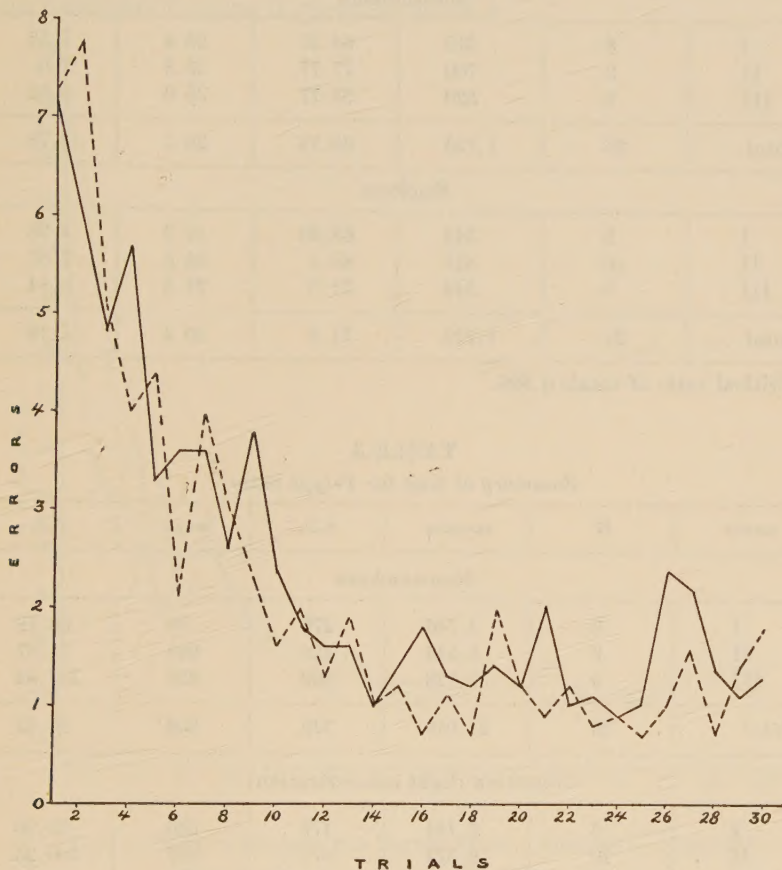


FIG. 5. ERRORS IN Y-TYPE MAZE. GROUPS I, II, AND III
Non-smokers----- Smokers ———

The mean time for the smokers of group II is less than that of the non-smokers in the group. This is the only case in these three groups where the mean of the smokers is lower than that of the non-smokers. The probable errors of the means, however, are much greater than the difference in each case.

TABLE 2
Summary of errors for Y-type maze

GROUP	N	ERRORS	MEAN	S.D.	P.E.
Non-smokers					
I	8	515	64.37	23.4	7.58
II	9	700	77.77	33.8	7.6
III	9	520	57.77	25.0	5.62
Total	26	1,735	66.73	28.5	3.78
Smokers					
I	5	343	68.38	14.2	4.28
II	10	831	83.1	35.5	7.57
III	9	549	61.0	27.3	6.14
Total	24	1,723	71.8	30.4	4.18

Critical ratio of totals 0.898.

TABLE 3
Summary of time for Y-type maze

GROUP	N	SECONDS	S.D.	MEAN	P.E.
Non-smokers					
I	8	4,746	276	93	66.78
II	9	8,545	332	949	74.87
III	9	7,728	480	858	107.92
Total	26	21,019	376	808	49.81
Smokers (light concentration)					
I	5	3,181	177	636	53.96
II	10	9,371	470	937	100.25
III	9	6,070	263	674	59.36
Total	24	18,622	353	774	48.56

Critical ratio of totals 0.457.

The similarity of the daily time scores for the smokers and non-smokers is brought out in figure 6. The ordinates represent the mean number of seconds consumed by the smokers and non-smokers, and the abscissae represent the trials.

Groups IV and V were given the same problem. The smokers in these groups were exposed to the relatively heavy concentration of smoke, and for this reason the groups are considered together. The summary of errors made by these two groups in the multiple Y maze is given in table 4.

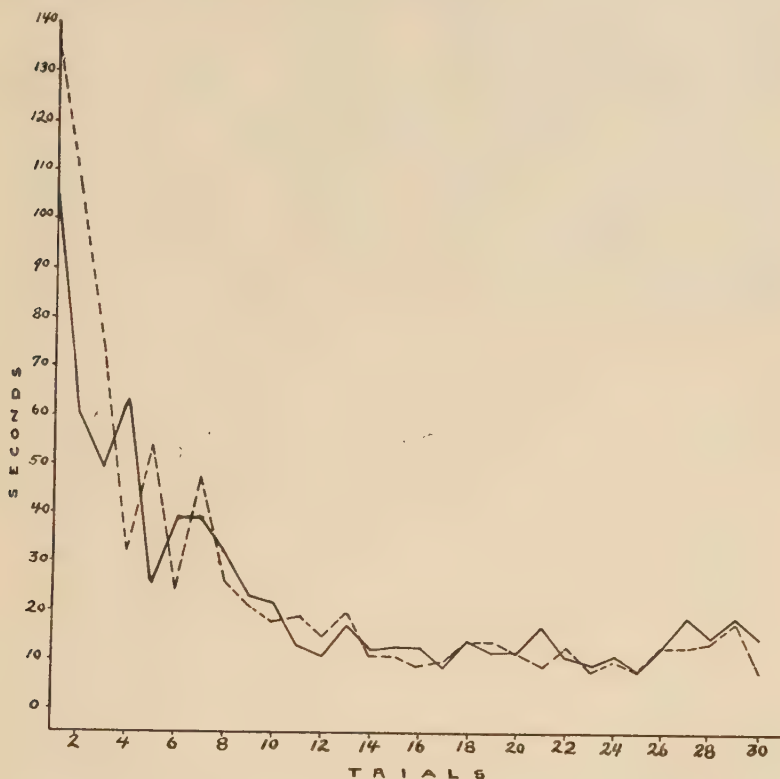


FIG. 6. TIME IN SECONDS FOR Y-TYPE MAZE. GROUPS I, II, AND III
Non-smokers----- Smokers ———

Since there was a slight difference between the smokers and non-smokers in the first three groups, it was thought that a greater concentration of smoke might increase this difference. Instead of finding a greater difference between the means with the increased concentration, the difference decreased to less than 1 in both groups. With the probable error of the mean greater than 1 for both groups, the critical ratio is insignificant.

TABLE 4
Summary of errors for Y-type maze

GROUP	N	ERRORS	MEAN	S.D.	P.E.
Non-smokers					
IV	11	675	61.36	19.2	5.69
V	4	205	51.25	4.4	1.48
Total.....	15	880	58.66	17.1	2.97
Smokers (heavy concentration)					
IV	8	496	62.0	19.7	4.63
V	5	260	52.0	7.1	2.15
Total.....	13	756	58.2	16.7	3.1

Critical ratio 0.107.

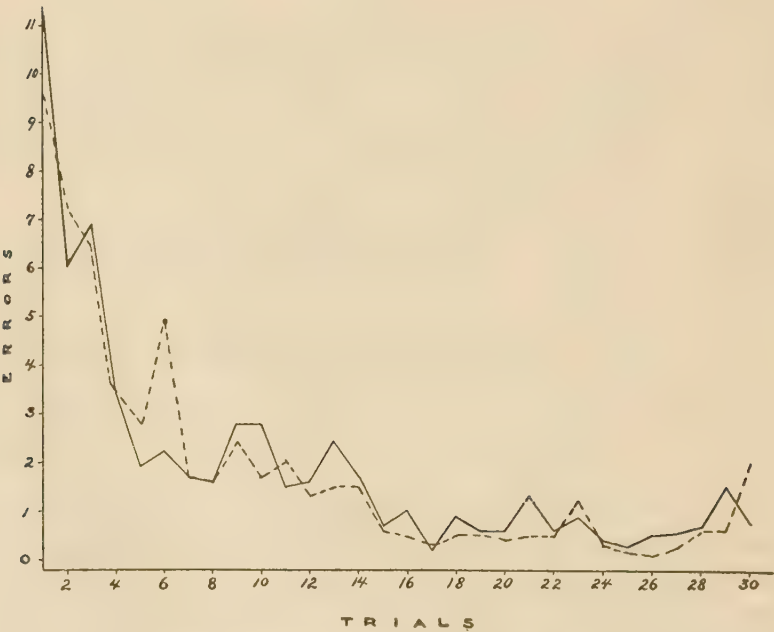


FIG. 7. ERRORS IN Y-TYPE MAZE. GROUPS IV AND V
Non-smokers — Smokers - - - - -

TABLE 5
Summary of time for Y-type maze

GROUP	N	SECONDS	S.D.	MEAN	P.E.
Non-smokers					
IV	11	8,134	234	379	47.7
V	4	2,026	101	507	34.1
Total.....	15	10,160	215	677	40.6
Smokers (heavy concentration)					
IV	8	5,679	372	709	89.7
V	5	3,167	80	633	24.13
Total.....	13	8,846	292	681	54.62

Critical ratio of totals 0.056.

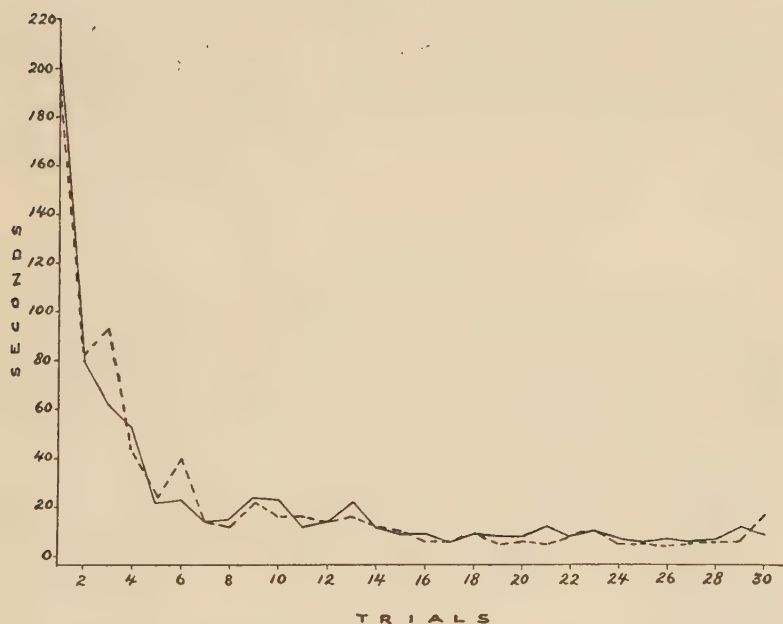


FIG. 8. TIME IN SECONDS FOR Y-TYPE MAZE. GROUPS IV AND V
Non-smokers ——— Smokers - - - - -

Figure 7 shows the learning curves for these two groups in terms of errors and trials. The graph for the errors of groups I, II and III showed a slight difference in the curves for the smokers and non-smokers. Figure 7 shows that with the increased concentration of smoke the difference does not increase.

The time record for groups IV and V in the multiple Y-maze is given in table 5.

The smokers in group IV have a smaller mean time than the non-smokers in the group. The mean for the total for the two groups is smaller in the case of the non-smokers. The difference, however, is so slight that it is negligible. The point deserves mentioning in so far as it agrees with the results shown in table 4, namely, the difference between the smokers and non-smokers decreased when the smokers were exposed to the heavier concentration of smoke.

Figure 8 shows the learning curves for groups IV and V in terms of time and trials. The mean number of seconds consumed by the non-smokers in groups IV and V, in completing each trial, is represented by the solid line, while that of the smokers is represented by the broken line. The graph illustrates the similarity of the learning curves for the smokers and non-smokers.

ALTERNATION PROBLEM

All the animals were given this problem three days after completing the multiple Y-maze. This problem was selected to ascertain whether differential motivation due to loss of appetite because of the smoke played a part in the results obtained in the maze learning experiment. It was possible that the appetite of the smokers might have been lessened by the action of smoke on their digestive system. This loss of appetite would affect their motivation and performance in the multiple Y-maze where food was the reward. In this problem, escape from shock was the motivation.

The procedure and criterion of mastery for this problem have

been described earlier. The number of trials and errors made in attaining this criterion was recorded. The individual records for the animals on this problem are given in tables 6 and 7.

TABLE 6
Alternation problem

GROUP		ANIMALS							TOTAL	MEAN
		I	II	III	IV	V	VI	VII		
I	Non-smokers:									
	Trials.....	21	5	4	5	19	21	14	89	12.7
	Errors.....	19	18	9	9	21	12	14	112	16
	Smokers:	I	II	III	IV	V	VI			
	Trials.....	11	8	16	15	4	9		63	10.5
	Errors.....	12	9	13	13	8	10		65	10.8
II	Non-smokers:	I	II	III	IV	V	VI	VII	VIII	IX
	Trials.....	8	12	7	16	10	17	15	6	4
	Errors.....	11	12	7	20	10	17	14	7	7
	Smokers:	I	II	III	IV	V	VI	VII	VIII	IX
	Trials.....	11	17	13	7	5	7	20	55	14
	Errors.....	10	21	13	7	6	7	21	43	6
III	Non-smokers:	I	II	III	IV	V	VI	VII		
	Trials.....	30	20	6	13	28	8	7		
	Errors.....	26	20	13	21	21	9	6		
	Smokers:	I	II	III	IV	V	VI	VII	VIII	IX
	Trials.....	10	5	13	36	5	12	34	19	18
	Errors.....	10	6	10	30	9	12	29	13	18

The smokers in groups I, II and III were exposed to the same light concentration of smoke. The number of trials and errors made by these groups is considered together in table 8.

There is a small difference between the mean number of errors

for these groups, but the difference between the mean number of trials is greater than the probable error of the mean. The differ-

TABLE 7
Alternation problem

GROUP		ANIMALS											TOTAL	MEAN
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI		
IV	Non-smokers:													
	Trials	5	12	20	4	7	6	5	16	13	19	10	117	10.6
	Errors	18	12	20	9	7	13	9	20	21	21	10	160	14.5
	Smokers:	I	II	III	IV	V	VI	VII	VIII					
	Trials	8	17	5	16	13	15	15	7				86	10.7
V	Non-smokers:	I		II		III		IV						
	Trials	14		15		7		8					44	11
	Errors	14		14		6		9					42	10.5
	Smokers:	I		II		III		IV		V				
	Trials	9		7		12		15		7			50	10
	Errors	10		7		12		20		7			56	11.2

TABLE 8
Alternation problem
Summary of trials and errors for groups I, II, III

	NON-SMOKERS (TWENTY-THREE ANIMALS)		SMOKERS (THIRTEEN ANIMALS)	
	Errors	Trials	Errors	Trials
Total	344	266	336	364
Mean	14.9	12.4	14	15.2
S.D.	4.2	8.2	7.1	8.8
P.E.	0.58	1.15	1.26	1.84

Critical ratio for errors 0.46. Critical ratio for trials 1.59.

ence favors the non-smokers, but it is not statistically significant.

Groups IV and V were exposed to the heavier concentration of smoke. The number of trials and errors made by these two groups on the alternation problem is considered in table 9.

The smokers in these groups made fewer errors than the non-smokers, but the difference between the smokers and non-smokers in number of trials is negligible. The smokers considered in table 8 were exposed to a lighter concentration of smoke, and they required more trials than the non-smokers to master the alternation problem. The animals considered in this table were exposed to the heavier concentration of smoke. In

TABLE 9
Alternation problem
Summary of trials and errors for groups IV and V

	NON-SMOKERS (FIFTEEN ANIMALS)		SMOKERS (THIRTEEN ANIMALS)	
	Errors	Trials	Errors	Trials
Total.....	202	161	148	136
Mean.....	13.3	10.7	11.4	10.5
S.D.....	5.6	5.1	4.8	3.4
P.E.....	0.94	0.88	0.89	0.61

Critical ratio for errors 1.14. Critical ratio for trials 0.18.

this case, the difference favors the smokers, but it is not statistically significant.

CONCLUSION

The apparatus was designed to expose animals to different concentrations of smoke for varying degrees of time. Since animals in a smoke-filled box would be forced to inhale the tobacco smoke, they would be exposed to the harmful ingredients contained therein. The situation was different from that in which a human being finds himself in an ordinary smoke-filled room. Smoke is chemically different after it has been taken into the mouth and exhaled (3), while in this situation fresh smoke was being constantly drawn into the box. Certain minor difficulties in this respect were encountered in that the animals huddled one upon another at the end of the box opposite the smoke

inlet. The harmful ingredients of the smoke breathed by those at the bottom of the pile may have been filtered out. This may have been accomplished either by the inhalation of the smoke by the animals on the top of the pile or by the passage of the smoke through the hair of those rats. The huddling was not constant, however, and there were frequent changes of positions throughout the period. In each experiment the groups were so small that the majority were inhaling fresh smoke most of the time.

If this point is accepted, we may compare the two groups as smokers and non-smokers. It was difficult for the animals to master the multiple Y maze, since they had only one trial a day. If smoking had a deleterious effect on the learning of the smokers, either the maze or the alternation problem brought out a difference. If the effects were cumulative then the alternation problem should have proved effective, since the animals had been exposed to the smoke for 30 days before attempting this problem.

No critical ratio of the means for the smokers and non-smokers was statistically significant. The figures illustrate the similarity of the learning curves of the experimental and control animals. It may be concluded that, the learning of albino rats is not affected when they are exposed for forty-five minutes a day to the relatively light or heavy concentration of tobacco smoke used.

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VITA

Harold C. Phillips was born in Butte, Montana, November 19, 1906. He attended St. Joseph's Parochial School of that city for eight years. After one year in Butte Central High School, he went to St. Vincent Preparatory School. His High School education was completed here in 1924. He attended St. Vincent College during the years 1924-26, 1927-30. The school year 1926-27 was spent in the Novitiate at St. Vincent Archabbey. In 1929 he completed his college course at St. Vincent College and received the degree of Bachelor of Arts. After two years of graduate work in psychology, he received the degree of Master of Arts in 1931, from the same college. During the summer of 1931, he studied psychology at the Catholic University of America. In 1932 he taught psychology at St. Vincent College. The years 1933-36 were spent in graduate work in psychology at Johns Hopkins University.

